

Please type a plus sign (+) inside this box → ☐

PTO/SB/05 (2/98)  
Approved for use through 09/30/00. OMB 0651-0032  
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE  
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	03364.P021
First Inventor or Application Identifier	Ho-Jin Kweon
Title	POSITIVE ACTIVE MATERIAL FOR RECHARGEABLE LITHIUM BATTERY AND METHOD OF PREPARING SAME
Express Mail Label No.	EM522829098US

## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents

ADDRESS TO: Assistant Commissioner for Patents  
Box Patent Application  
Washington, DC 20231

1. ☒ Fee Transmittal Form  
(Submit an original, and a duplicate for fee processing)
2. ☒ Specification Total Pages   
(preferred arrangement set forth below)
- Descriptive title of the Invention
  - Cross References to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to Microfiche Appendix
  - Background of the Invention
  - Brief Summary of the Invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claim(s)
  - Abstract of the Disclosure

3. ☒ Drawing(s) (35 CFR 113) Total Sheets

4. Oath or Declaration Total Pages

- a. ☒ Newly executed (original copy)
- b. ☐ Copy from a prior application (37 CFR 1.63(d))  
(for continuation/divisional with Box 16 completed)  
[Note Box 5 below]
- i. ☐ **DELETION OF INVENTOR(S)**  
Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).

\*NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

5. ☐ Microfiche Computer Program (Appendix)
6. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
- a. ☐ Computer Readable Copy
- b. ☐ Paper Copy (identical to computer copy)
- c. ☐ Statement verifying identity of above copies

## ACCOMPANYING APPLICATION PARTS

7. ☒ Assignment Papers (cover sheet & document(s))
8. ☐ 37 CFR 3.73(b) Statement (when there is an assignee) ☐ Power of Attorney
9. ☐ English Translation Document (if applicable)
10. ☐ Information Disclosure Statement (IDS)/PTO - 1449 ☐ Copies of IDS Citations
11. ☐ Preliminary Amendment
12. ☒ Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
13. ☐ \*Small Entity Statement filed in prior application, Statement(s) ☐ Status still proper and desired
14. ☒ Certified Copy of Priority Document(s) (if foreign priority is claimed)
15. ☒ Other: submission of formal drawings; . . . . request for priority . . . . .

16. If a **CONTINUING APPLICATION**, check appropriate box, and supply the requisite information below and in a preliminary amendment:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No: \_\_\_\_\_

Prior application Information: Examiner \_\_\_\_\_

Group/Art Unit: \_\_\_\_\_

For **CONTINUATION** or **DIVISIONAL APPS** only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

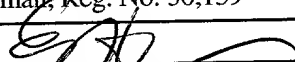
## 17. CORRESPONDENCE ADDRESS

☐ Customer Number of Bar Code Label

(Insert Customer No. or Attach bare code label here)

or ☒ Correspondence address below

Name	BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP				
Address	12400 Wilshire Boulevard, Seventh Floor				
City	Los Angeles	State	California	Zip Code	90025
Country	U.S.A.	Telephone	(310) 207-3800	Fax	(310) 820-5988

Name (Print/Type)	Eric S. Hyman, Reg. No. 30,139		
Signature		Date	10/29/99

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

# POSITIVE ACTIVE MATERIAL FOR RECHARGEABLE LITHIUM BATTERY AND METHOD OF PREPARING SAME

## BACKGROUND OF THE INVENTION

### (a) Field of the Invention

5           The present invention relates to a positive active material for rechargeable lithium batteries and a method of preparing the same and, more particularly, to a manganese-based positive active material for rechargeable lithium batteries which has a good cycle life characteristic.

### (b) Description of the Related Art

10           Generally, manganese-based compounds such as  $\text{LiMn}_2\text{O}_4$  and  $\text{LiMnO}_2$  are the positive active material of choice for rechargeable lithium batteries because of their low cost, abundance and environmentally friendly characteristics. Among such manganese-based compounds,  $\text{LiMn}_2\text{O}_4$  is particularly stable for the battery use and thus attractive for the electric vehicle  
15           application.

          However, as compared to other lithiated transition metal oxides such as  $\text{LiCoO}_2$  and  $\text{LiNiO}_2$ ,  $\text{LiMn}_2\text{O}_4$  has a relatively low discharge capacity. Furthermore, when high rate of charge and discharge operations are cycled, the discharge capacity is excessively reduced. In particular, when the charge  
20           and discharge operations are continuously performed at high temperatures, manganese distributed in the surface of  $\text{LiMn}_2\text{O}_4$  readily elutes to the electrolyte, causing a disproportionation reaction. This reaction seriously deteriorates the

cycle life characteristic of the battery.

### SUMMARY OF THE INVENTION

It is an object of the present invention to provide a manganese-based positive active material for rechargeable lithium batteries which exhibits a good cycle life characteristic at high temperatures.

This and other objects may be achieved by a positive active material for rechargeable lithium batteries including an active material component processed from a manganese-based compound. The manganese-based compound is selected from  $\text{Li}_x\text{MnO}_2$ ,  $\text{Li}_x\text{MnF}_2$ ,  $\text{Li}_x\text{MnS}_2$ ,  $\text{Li}_x\text{MnO}_{2-z}\text{F}_z$ ,  $\text{Li}_x\text{MnO}_{2-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{F}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{S}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_{2-z}\text{F}_z$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_{2-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_2\text{O}_4$ ,  $\text{Li}_x\text{Mn}_2\text{F}_4$ ,  $\text{Li}_x\text{Mn}_2\text{S}_4$ ,  $\text{Li}_x\text{Mn}_2\text{O}_{4-z}\text{F}_z$ ,  $\text{Li}_x\text{Mn}_2\text{O}_{4-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{F}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{S}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_{4-z}\text{F}_z$ , or  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_{4-z}\text{S}_z$  where  $0 < x \leq 1.5$ ,  $0.05 \leq y \leq 0.3$ ,  $z \leq 1.0$  and M is selected from Al, Co, Cr, Mg, Fe or La. A metallic oxide is coated on the active material component.

A method of preparing the positive active material is performed by obtaining a powder from a source material. The source material is selected from  $\text{Li}_x\text{MnO}_2$ ,  $\text{Li}_x\text{MnF}_2$ ,  $\text{Li}_x\text{MnS}_2$ ,  $\text{Li}_x\text{MnO}_{2-z}\text{F}_z$ ,  $\text{Li}_x\text{MnO}_{2-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{F}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{S}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_{2-z}\text{F}_z$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_{2-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_2\text{O}_4$ ,  $\text{Li}_x\text{Mn}_2\text{F}_4$ ,  $\text{Li}_x\text{Mn}_2\text{S}_4$ ,  $\text{Li}_x\text{Mn}_2\text{O}_{4-z}\text{F}_z$ ,  $\text{Li}_x\text{Mn}_2\text{O}_{4-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{F}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{S}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_{4-z}\text{F}_z$ , or  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_{4-z}\text{S}_z$ , where  $0 < x \leq 1.5$ ,  $0.05 \leq y \leq 0.3$ ,  $z \leq 1.0$  and M is selected from Al, Co, Cr, Mg, Fe or La. The powder is then coated with a metallic alkoxide solution to make an alkoxide-coated powder. Thereafter, the

metallic alkoxide-coated powder is heat-treated such that it is changed into a metallic oxide-coated powder.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

A more complete appreciation of the invention, and many of the attendant advantages thereof, will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings, wherein:

Fig. 1 is a graph illustrating high-temperature charge and discharge characteristics of rechargeable lithium cells according to an example of the present invention and a comparative example;

Fig. 2 is a graph illustrating high-temperature cycle life characteristics of the rechargeable lithium cells of Fig. 1; and

Fig. 3 is a graph illustrating SIMS analysis results with respect to a rechargeable lithium cell according to another example of the present invention.

### **DETAILED DESCRIPTION OF THE INVENTION**

In a method of preparing a positive active material for rechargeable lithium batteries, a powder, being an active material precursor, is first processed from a manganese-based compound. The manganese-based compound is selected from  $\text{Li}_x\text{MnO}_2$ ,  $\text{Li}_x\text{MnF}_2$ ,  $\text{Li}_x\text{MnS}_2$ ,  $\text{Li}_x\text{MnO}_{2-z}\text{F}_z$ ,  $\text{Li}_x\text{MnO}_{2-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{F}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{S}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_{2-z}\text{F}_z$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_{2-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_2\text{O}_4$ ,  $\text{Li}_x\text{Mn}_2\text{F}_4$ ,  $\text{Li}_x\text{Mn}_2\text{S}_4$ ,  $\text{Li}_x\text{Mn}_2\text{O}_{4-z}\text{F}_z$ ,  $\text{Li}_x\text{Mn}_2\text{O}_{4-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{F}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{S}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_{4-z}\text{F}_z$ , or  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_{4-z}\text{S}_z$ , where  $0 < x \leq 1.5$ ,

0.05≤y≤0.3, z≤1.0 and M is selected from Al, Co, Cr, Mg, Fe or La. The powder processing step can be performed with a technique known in the related art.

Thereafter, the powder is coated with a metallic alkoxide solution. The metallic alkoxide solution is formed by the reaction of an alcohol with an alkali metal being 1 to 50 weight percent of the alcohol. The alkali metal may be preferably selected from Mg, Al, Co, K, Na, Ca, Si, Ti or Sr. More preferably, the alkali metal is selected from Si, Mg, Ti or Al. The alcohol is preferably selected from methanol or ethanol. When the alkali metal is less than 1 weight percent of the alcohol, the coating effect of the metallic alkoxide solution onto the powder is not induced. In contrast, when the alkali metal is more than 50 weight percent of the alcohol, the coating layer of the metallic alkoxide solution becomes undesirably thick. A sputtering technique, a chemical vapor deposition (CVD) technique, a dip coating technique and other general-purpose coating techniques may be employed for the coating use. Among the techniques, the dip coating technique may be preferably used for coating the metallic alkoxide solution onto the powder.

The alkoxide-coated powder is then dried at 120°C for about 5 hours in an oven. The drying step is to uniformly distribute lithium salts in the powder. Thereafter, the dried powder is heat-treated at temperatures ranged from 200 to 1000°C for 1 to 20 hours under an oxidation atmosphere where dry air or oxygen is blowing. When the heat-treating temperature is lower than 200°C, the metallic alkoxide solution coated on the powder is not crystallized so that it

prohibits free movement of lithium ions in the active material. It is preferable that the heat-treating step is performed at temperatures ranged from 300 to 900°C for 1 to 10 hours. This heat-treating operation makes the metallic alkoxide to be changed into a metallic oxide. In this way, a metallic oxide-coated active material is prepared.

The metallic oxide formed on the surface of the power may be derived from the single metallic alkoxide source or the composite sources of manganese of lithiated transition metal compound and metallic alkoxide. The thickness of the metallic oxide layer reaches up to 1 to 100nm and the quantity of metal content is ranged from 0.1 to 10 weight percent of the metallic oxide.

The following examples further illustrate the present invention.

#### Example 1

An aluminum isopropoxide solution having a 5 weight-percent concentration was prepared by refluxing an aluminum isopropoxide powder in ethanol at about 100°C for about half an hour. The aluminum isopropoxide solution was then mixed with a powder of  $\text{Li}_x\text{Mn}_{2-y}\text{Al}_y\text{O}_{4-z}\text{F}_z$  where  $0 < x \leq 1.5$ ,  $0.05 \leq y \leq 0.3$  and  $z \leq 1.0$  at an identical volume ratio in a moisture free dry room such that an overall surface of the power became wet sufficiently by the solution, and dried in the same room. Thereafter, the mixture was heat-treated at about 300°C for about 10 hours under a dry air atmosphere to thereby prepare a metallic oxide-coated active material. Then, the active material was mixed with Super P carbon for a conductive agent, KF-1300 polyvinylidene fluoride for a binder and N-methylpyrrolidone for a solvent to prepare an active

material slurry. The slurry is cast into a tape shape to act as a positive electrode. The positive electrode is then assembled with a lithium metal foil for an opposite pole by using a lithium salt solution for an electrolyte to thereby fabricate a coin cell-type half cell. The lithium salt solution contained 1:1  
5 volume ratio of ethylene carbonate and dimethyl carbonate for a solvent and  $\text{LiPF}_6$  for a solute.

### Example 2

The positive electrode preparing procedure was performed in the same way as in Example 1 with the exception that the heat-treating temperature was  
10 heightened up to  $900^\circ\text{C}$ . A coin-type half cell was fabricated with the resulting positive electrode in combination with other components as described in Example 1.

### Example 3

An aluminum isopropoxide solution having a 5 weight-percent  
15 concentration was prepared by refluxing an aluminum isopropoxide powder in ethanol at about  $100^\circ\text{C}$  for about half an hour. The aluminum isopropoxide solution was then mixed with a powder of  $\text{Li}_x\text{Mn}_2\text{O}_4$  where  $0 < x \leq 1.5$  at an identical volume ratio in a moisture free dry room such that an overall surface of the powder became wet sufficiently by the solution, and dried in the same room.  
20 Thereafter, the mixture was heat-treated at about  $300^\circ\text{C}$  for about 10 hours under a dry air atmosphere to thereby prepare a metallic oxide-coated active material. The subsequent positive electrode processing steps were performed in the same way as in Example 1. A coin-type half cell was fabricated with the

resulting positive electrode in combination with other components as described in Example 1.

#### Comparative Example 1

The positive electrode preparing procedure was performed in the same way as in Example 1 with the exception that  $\text{Li}_x\text{Mn}_{2-y}\text{Al}_y\text{O}_{4-z}\text{F}_z$  was directly used for the active material without the metallic-alkoxide coating operation. A coin-type half cell was fabricated with the resulting positive electrode in combination with other components as described in Example 1.

The coin type cells fabricated according to Example 1 and Comparative Example 1 were charged and discharged at 50°C from 0.1C to 1C rate over the voltage window between 4.3V and 3.0V. The charge and discharge characteristics of the cells in the early cycles were illustrated in Fig. 1. Further, the cycle life characteristics of the cells were illustrated in Fig. 2. In each of the figures, the charge and discharge characteristic of the cell according to Example 1 is indicated by a parenthesized alphabetic symbol “(a)” and that of the cell according to Comparative Example 1 is indicated by another symbol “(b)”. As shown in Figs. 1 and 2, the cell according to Example 1 exhibited a slightly lower specific capacity but a better cycle life characteristic at high temperatures than the cell according to Comparative Example 1. It is presumed that the good cycle life characteristic of the cell is resulted because the metallic oxide layer coated on the surface of the manganese-based active material component prevents elution of manganese to the electrolyte. The cells fabricated according to Examples 2 and 3 also exhibited the desired

performance characteristic similar to that of Example 1.

Meanwhile, a secondary ion mass spectrometry (SIMS) analysis was performed with respect to the positive active material prepared according to Example 3 to measure the component distribution ratio. The result was illustrated in Fig. 3. In the figure, the relative intensity of the aluminum component is indicated by a parenthesized alphabetic symbol "(a)" and that of the manganese component is indicated by another symbol "(b)". As shown in Fig. 3, it could be known that the aluminum component existed more in the surface portion of the active material and the manganese component existed more in the center portion of the active material. This proved that the overall surface of  $\text{Li}_x\text{Mn}_2\text{O}_4$  was completely coated with aluminum oxide.

As described above, the positive active material for rechargeable lithium batteries has a good high-temperature cycle life characteristic.

While the present invention has been described in detail with reference to the preferred embodiments, those skilled in the art will appreciate that various modifications and substitutions can be made thereto without departing from the spirit and scope of the present invention as set forth in the appended claims.

## **WHAT IS CLAIMED IS:**

1. A positive active material for rechargeable lithium batteries, the positive active material comprising:

an active material component processed from a manganese-based compound, the manganese-based compound being selected from the group consisting of  $\text{Li}_x\text{MnO}_2$ ,  $\text{Li}_x\text{MnF}_2$ ,  $\text{Li}_x\text{MnS}_2$ ,  $\text{Li}_x\text{MnO}_{2-z}\text{F}_z$ ,  $\text{Li}_x\text{MnO}_{2-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{F}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{S}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_{2-z}\text{F}_z$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_{2-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_2\text{O}_4$ ,  $\text{Li}_x\text{Mn}_2\text{F}_4$ ,  $\text{Li}_x\text{Mn}_2\text{S}_4$ ,  $\text{Li}_x\text{Mn}_2\text{O}_{4-z}\text{F}_z$ ,  $\text{Li}_x\text{Mn}_2\text{O}_{4-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{F}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{S}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_{4-z}\text{F}_z$ , and  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_{4-z}\text{S}_z$  where  $0 < x \leq 1.5$ ,  $0.05 \leq y \leq 0.3$ ,  $z \leq 1.0$  and M is selected from the group consisting of Al, Co, Cr, Mg, Fe and La; and

a metallic oxide coated on the active material component.

2. The positive active material of claim 1 wherein the metallic oxide has a metal component selected from the group consisting of Si, Mg, Ti and Al.

3. The positive active material of claim 1 wherein the metallic oxide has a thickness ranged from 1 to 100nm.

4. The positive active material of claim 1 wherein the metallic oxide has a 0.1 to 10 weight percent of metal component.

5. A method of preparing a positive active material for rechargeable lithium batteries, the method comprising the steps of:

obtaining a powder from a source material, the source material being selected from the group consisting of  $\text{Li}_x\text{MnO}_2$ ,  $\text{Li}_x\text{MnF}_2$ ,  $\text{Li}_x\text{MnS}_2$ ,  $\text{Li}_x\text{MnO}_{2-z}\text{F}_z$ ,  $\text{Li}_x\text{MnO}_{2-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{F}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{S}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_{2-z}\text{F}_z$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_{2-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_2\text{O}_4$ ,  $\text{Li}_x\text{Mn}_2\text{F}_4$ ,  $\text{Li}_x\text{Mn}_2\text{S}_4$ ,  $\text{Li}_x\text{Mn}_2\text{O}_{4-z}\text{F}_z$ ,  $\text{Li}_x\text{Mn}_2\text{O}_{4-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{F}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{S}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_{4-z}\text{F}_z$ , and  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_{4-z}\text{S}_z$  where  $0 < x \leq 1.5$ ,  $0.05 \leq y \leq 0.3$ ,  $z \leq 1.0$  and M is selected from the group consisting of Al, Co, Cr, Mg, Fe and La; and

$yM_yO_{2-z}S_z$ ,  $Li_xMn_2O_4$ ,  $Li_xMn_2F_4$ ,  $Li_xMn_2S_4$ ,  $Li_xMn_2O_{4-z}F_z$ ,  $Li_xMn_2O_{4-z}S_z$ ,  $Li_xMn_{2-y}M_yO_4$ ,  $Li_xMn_{2-y}M_yF_4$ ,  $Li_xMn_{2-y}M_yS_4$ ,  $Li_xMn_{2-y}M_yO_{4-z}F_z$ , and  $Li_xMn_{2-y}M_yO_{4-z}S_z$  where  $0 < x \leq 1.5$ ,  $0.05 \leq y \leq 0.3$ ,  $z \leq 1.0$  and M is selected from the group consisting of Al, Co, Cr, Mg, Fe and La;

5                   coating the powder with a metallic alkoxide solution to make an alkoxide-coated powder; and

                  heat-treating the metallic alkoxide-coated powder such that the metallic alkoxide-coated powder is changed into a metallic oxide-coated powder.

6.           The method of claim 5 wherein the metallic alkoxide solution is  
10           selected from the group consisting of Si-alkoxide, Mg-alkoxide, Ti-alkoxide and Al-alkoxide.

7.           The method of claim 5 wherein the metallic alkoxide solution contains a 1 to 50 weight percent of metal component.

8.           The method of claim 5 wherein the heat-treating step is  
15           performed at temperatures ranged from 200 to 1000°C for 1 to 20 hours.

## **ABSTRACT OF THE DISCLOSURE**

A positive active material for rechargeable lithium batteries includes an active material component processed from a manganese-based compound.

The transition metal compound is selected from  $\text{Li}_x\text{MnO}_2$ ,  $\text{Li}_x\text{MnF}_2$ ,  $\text{Li}_x\text{MnS}_2$ ,

5  $\text{Li}_x\text{MnO}_{2-z}\text{F}_z$ ,  $\text{Li}_x\text{MnO}_{2-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{F}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{S}_2$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_{2-}$

$z\text{F}_z$ ,  $\text{Li}_x\text{Mn}_{1-y}\text{M}_y\text{O}_{2-z}\text{S}_z$ ,  $\text{Li}_x\text{Mn}_2\text{O}_4$ ,  $\text{Li}_x\text{Mn}_2\text{F}_4$ ,  $\text{Li}_x\text{Mn}_2\text{S}_4$ ,  $\text{Li}_x\text{Mn}_2\text{O}_{4-z}\text{F}_z$ ,  $\text{Li}_x\text{Mn}_2\text{O}_{4-z}\text{S}_z$ ,

$\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{F}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{S}_4$ ,  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_{4-z}\text{F}_z$ , or  $\text{Li}_x\text{Mn}_{2-y}\text{M}_y\text{O}_{4-z}\text{S}_z$

where  $0 < x \leq 1.5$ ,  $0.05 \leq y \leq 0.3$ ,  $z \leq 1.0$  and M is selected from Al, Co, Cr, Mg, Fe or

La. A metallic oxide is coated on the active material component.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

**Ho-Jin Kweon and Geun-Bae Kim**

For: POSITIVE ACTIVE MATERIAL FOR RECHARGEABLE  
LITHIUM BATTERY AND METHOD OF PREPARING SAME

JC678 U.S. PTO  
09/429262  
10/29/99

SUBMISSION OF FORMAL DRAWINGS

Assistant Commissioner for Patents  
Washington, D.C. 20231

Dear Sir:

Submitted herewith are Figures 1-3 in connection with the above-identified application.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Dated: 10/29/99

Eric S. Hyman Reg. No. 30, 139

12400 Wilshire Boulevard, Seventh Floor  
Los Angeles, California 90025  
(310) 207-3800

FIG.1

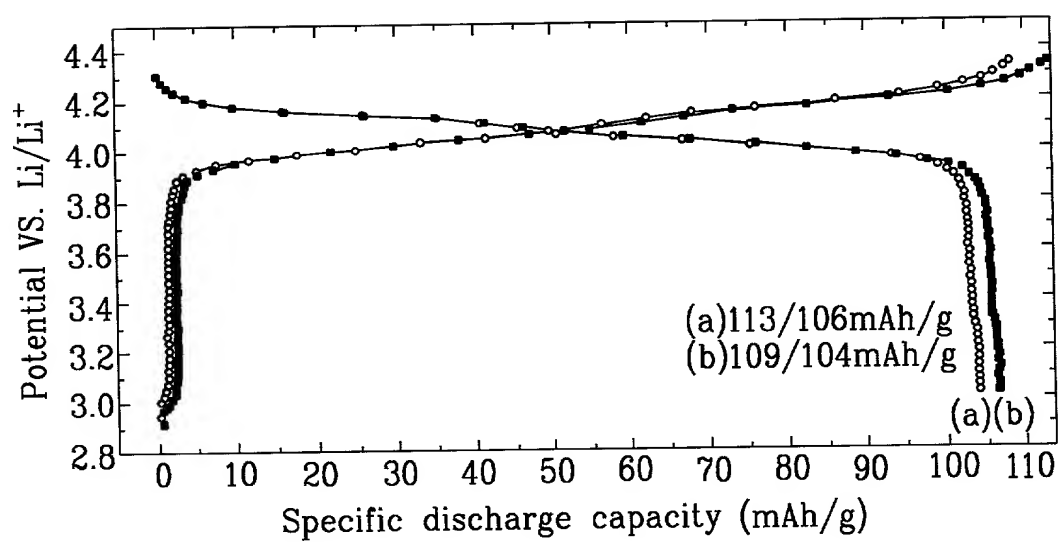


FIG.2

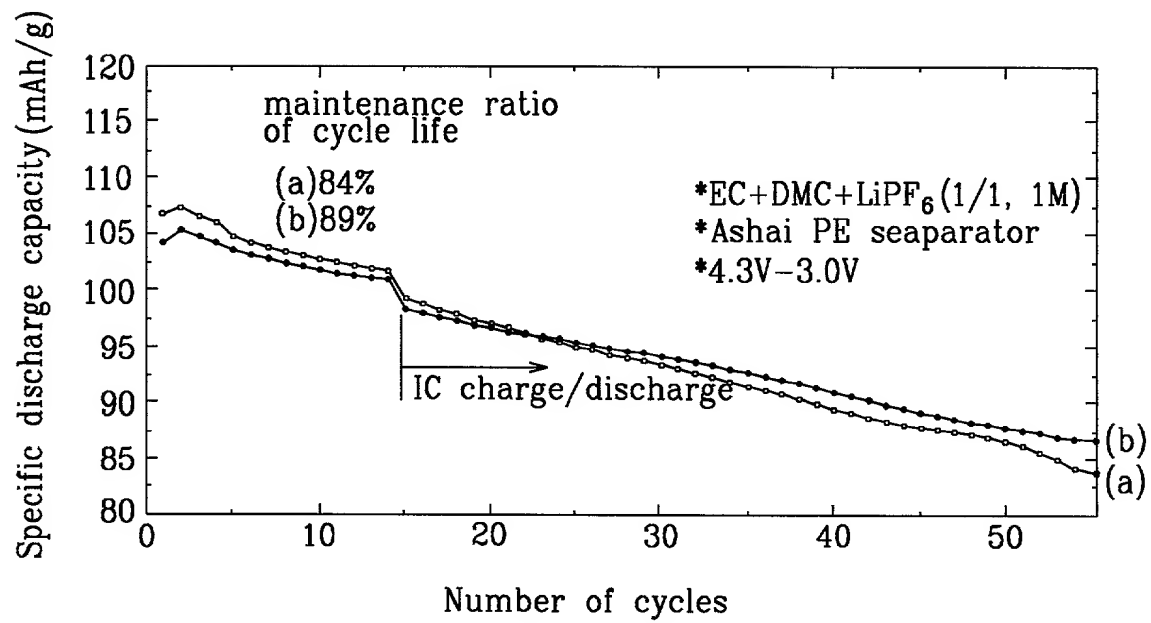
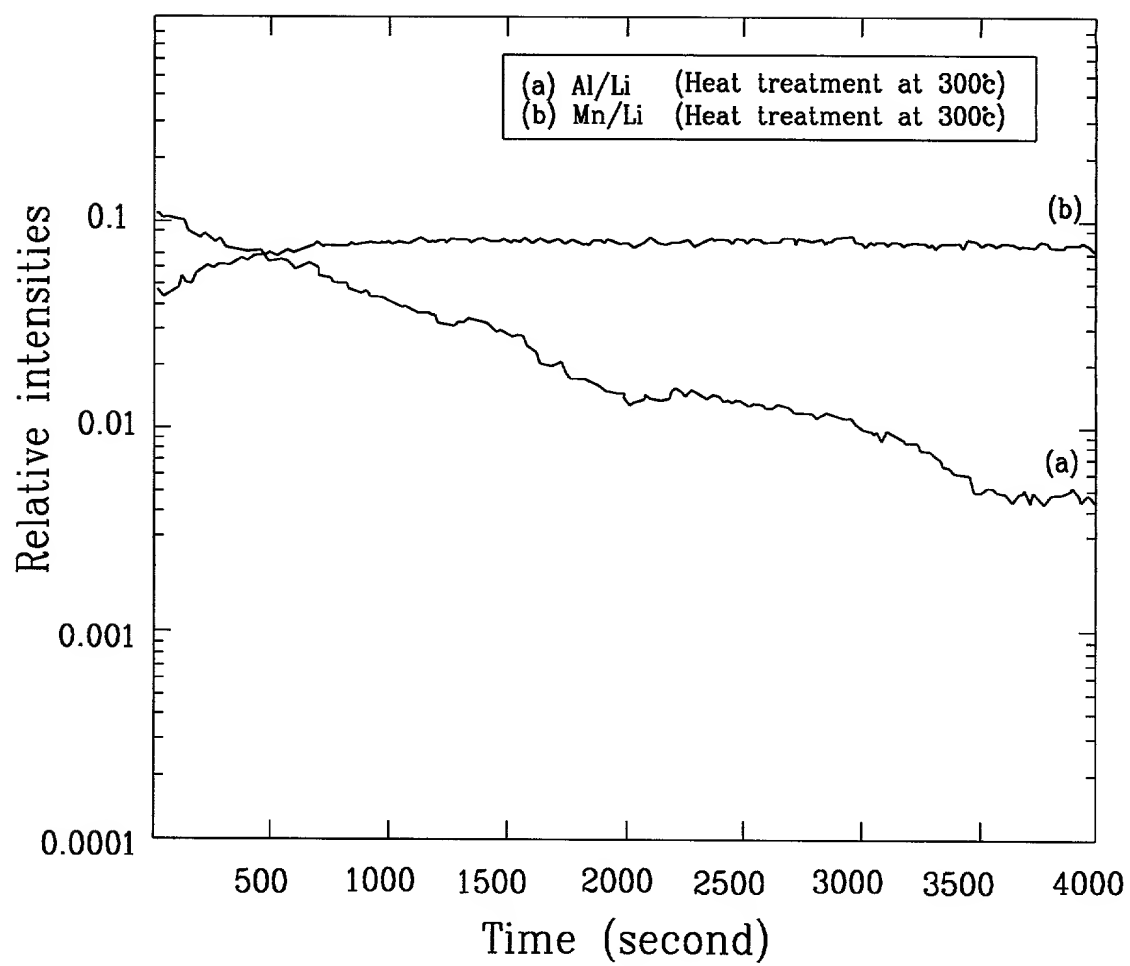


FIG.3



As a below named inventor, I hereby declare that:

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled "POSITIVE ACTIVE MATERIAL FOR RECHARGEABLE LITHIUM BATTERY AND METHOD OF PREPARING SAME"

      x      is attached hereto.  
      was filed on \_\_\_\_\_ as  
Application Serial No. \_\_\_\_\_  
and was amended on \_\_\_\_\_  
(if applicable)

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

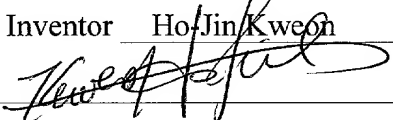
Prior Foreign Application(s)			Priority Claimed	
99-7430	Korea	06/03/1999	X	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

-1-

(Application Serial No.)	(Filing Date)	(Status -- patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status -- patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status -- patented, pending, abandoned)

I hereby appoint BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP, a firm including: Farzad E. Amini, Reg. No. 42,261; Aloysius T. C. AuYeung, Reg. No. 35,432; William Thomas Babbitt, Reg. No. 39,591; Carol F. Barry, 41,600; Jordan Michael Becker, Reg. No. 39,602; Bradley J. Bereznak, Reg. No. 33,474; Michael A. Bernadicou, Reg. No. 35,934; Roger W. Blakely, Jr., Reg. No. 25,831; Gregory D. Caldwell, Reg. No. 39,926; Kent M. Chen, Reg. No. 39,630; Lawrence M. Cho, Reg. No. 39,942; Yong S. Choi, Reg. No. 43,324; Thomas M. Coester, Reg. No. 39,637; Roland B. Cortes, Reg. No. 39,152; Barbara Bokanov Courtney, Reg. No. P42,442; William Donald Davis, Reg. No. 38,428; Michael Anthony DeSanctis, Reg. No. 39,957; Daniel M. De Vos, Reg. No. 37,813; Tarek N. Fahmi, Reg. No. P41,402; James Y. Go, Reg. No. 40,621; Richard Leon Gregory, Jr., P42,607; Dinu Gruia, Reg. No. 42,996; David R. Halvorson, Reg. No. 33,395; Thomas A. Hassing, Reg. No. 36,159; James A. Henry, Reg. No. 41,064; Phuong-Quan Hoang, 41,839; Willmore F. Holbrow III, Reg. No. P41,845; George W. Hoover II, Reg. No. 32,992; Eric S. Hyman, Reg. No. 30,139; Dag H. Johansen, Reg. No. 36,172; William W. Kidd, Reg. No. 31,772; Tim L. Kitchen, Reg. No. P41,900; Michael J. Mallie, Reg. No. 36,591; Paul A. Mendonsa P42,879; Darren J. Milliken, P42,004; Thinh V. Nguyen, Reg. No. 42,034; Kimberley G. Nobles, Reg. No. 38,255; Michael A. Proksch P43,021; Babak Redjaian, Reg. No. 42,096; James H. Salter, Reg. No. 35,668; William W. Schaal, Reg. No. 39,018; James C. Scheller, Reg. No. 31,195; Anand Sethuraman, Reg. No. 43,351; Charles E. Shemwell, Reg. No. 40,171; Maria McCormack Sobrino, Reg. No. 31,639; Stanley W. Sokoloff, Reg. No. 25,128; Allan T. Sponseller, Reg. No. 38,318; Geoffrey T. Staniford, P43,151; Judith A. Szepesi, Reg. No. 39,393; Vincent P. Tassinari, Reg. No. 42,179; Edwin H. Taylor, Reg. No. 25,129; George G. C. Tseng, Reg. No. 41,355; Lester J. Vincent, Reg. No. 31,460; John Patrick Ward, Reg. No. 40,216; Stephen Warhola, P43,237; Charles T. J. Weigell, Reg. No. 43,398; Ben J. Yorks, Reg. No. 33,609; and Norman Zafman, Reg. No. 26,250; my attorneys; and Amy M. Armstrong, Reg. No. P42,265; Robert Andrew Diehl, Reg. No. P40,992; and Edwin A. Sloane, Reg. No. 34,728; my patent agents, with offices located at 12400 Wilshire Boulevard, 7th Floor, Los Angeles, California 90025, telephone (310) 207-3800, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of First/Sole Inventor Ho Jin Kweon  
Inventor's Signature  Date 7/8/12  
Residence Cheonan-si, Chungcheongnam-do, Korea Citizenship Korea  
(City, State) (Country)

Post Office Address San 24, Seongseong-dong, Cheonan-si, Chungcheongnam-do, Korea

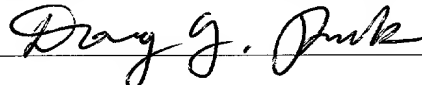
Full Name of Second/Joint Inventor.: Geun-Bae Kim

Inventor's Signature  Date August 2, 1999

Residence Cheonan-si, Chungcheongnam-do, Korea Citizenship Korea  
(City, State) (Country)

Post Office Address San 24, Seongseong-dong, Cheonan-si, Chungcheongnam-do, Korea

Full Name of Third/Joint Inventor : Dong-Gon Park

Inventor's Signature  Date 99/8/12

Residence Seoul, Korea Citizenship Korea  
(City, State) (Country)

Post Office Address Sookmyung Women's University, Cheongpa-dong 2-ga, Yongsan-ku, Seoul, Korea

Full Name of Fourth/Joint Inventor : Hyung-Gon Noh

Inventor's Signature  Date 99/08/03

Residence Cheonan-si, Chungcheongnam-do, Korea Citizenship Korea  
(City, State) (Country)

Post Office Address San 24, Seongseong-dong, Cheonan-si, Chungcheongnam-do, Korea